RHIC II /eRHIC accelerator plan

Electron cooling at RHIC

→ High brightness heavy ion beams

→ 10 fold RHIC luminosity upgrade

10 GeV electron ring:

→ eA and polarized ep collisions (eRHIC)

Costs and schedules

Readiness: 2 ("significant challenges not yet resolved")

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NSAC Subpanel Meeting
February 15, 2003

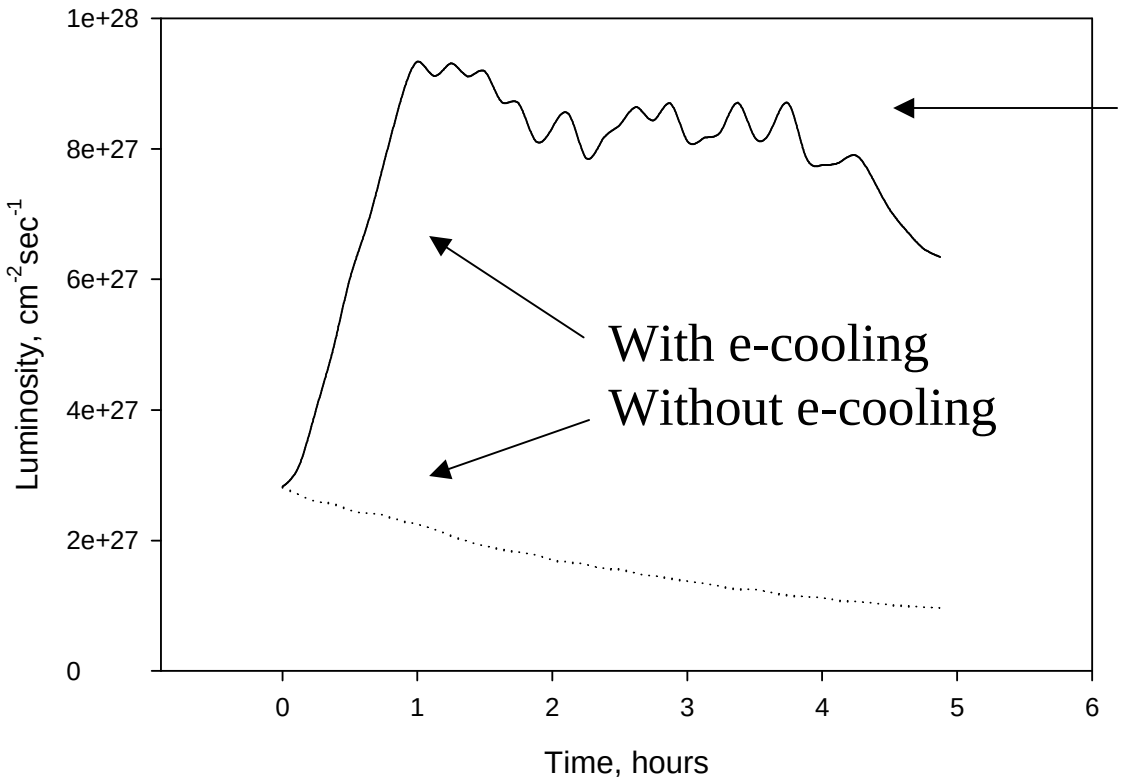
RHIC luminosity upgrade

- RHIC luminosity is limited by intra-beam scattering $\rightarrow$ beam cooling at full energy!
- Feasibility study by BINP (V. Parkhomchuk et al.): RHIC luminosity can be increased ten times.
- Bunched electron beam requirements for 100 GeV/u gold beams:
  E = 54 MeV, <I> ~ 100 mA, electron beam power: ~ 5 MW!
- Requires high brightness, high power, energy recovering superconducting linac, as demonstrated by JLab for IR FEL. (50 MeV, 5 mA)
- First linac based, bunched electron beam cooling system used at a collider
- First high p_t electron cooler to avoid recombination of e^- and Au^{79+}
- Maintains present bunch spacing (~ 100 ns) and available IR length
- Increased luminosity for pp and other species
- Longitudinal cooling possibly gives shorter diamond length

RHIC Luminosities with Electron Cooling

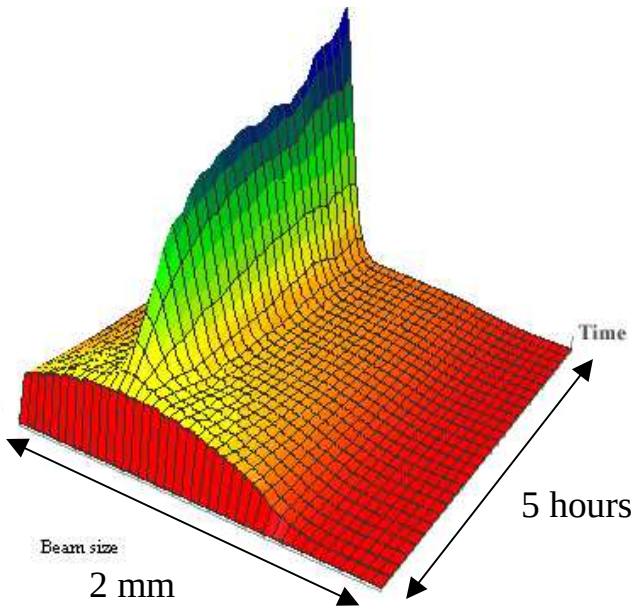
	w/o e-cooling	with e-cooling
Gold collisions (100 GeV/n x 100 GeV/n):		
Emittance (95%) πμm	15 → 40	15 → 3
Beta function at IR [m]	1.0	1.0 → 0.5
Number of bunches	112	112
Bunch population [10^9]	1	1 → 0.3
Beam-beam parameter per IR	0.0016	0.004
Peak luminosity [10^{26} cm^{-2} s^{-1}]	32	90
Average luminosity [10^{26} cm^{-2} s^{-1}]	8	70
Pol. Proton Collision (250 GeV x 250 GeV):		
Emittance (95%) πμm	20	12
Beta function at IR [m]	1.0	0.5
Number of bunches	112	112
Bunch population [10^{11}]	2	2
Beam-beam parameter per IR	0.007	0.012
Luminosity [10^{32} cm^{-2} s^{-1}]	2.4	8.0

RHIC Luminosity with and without Cooling

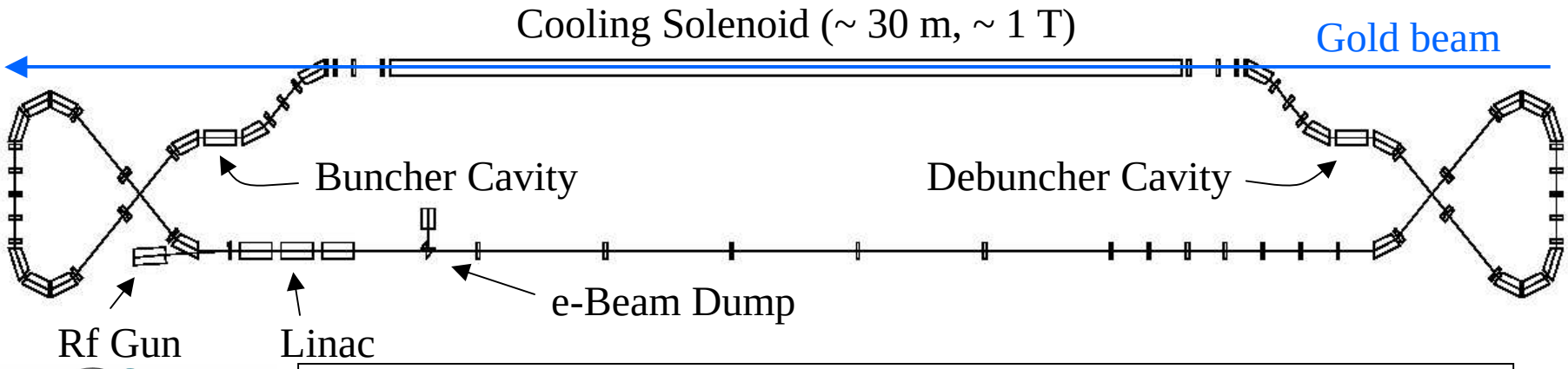


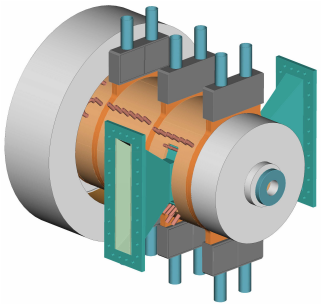
Luminosity leveling through continuous cooling and beta squeeze

Transverse beam profile during store



RHIC Electron Cooler R&D

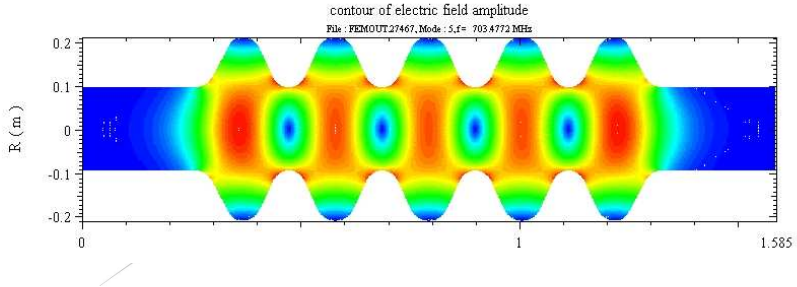


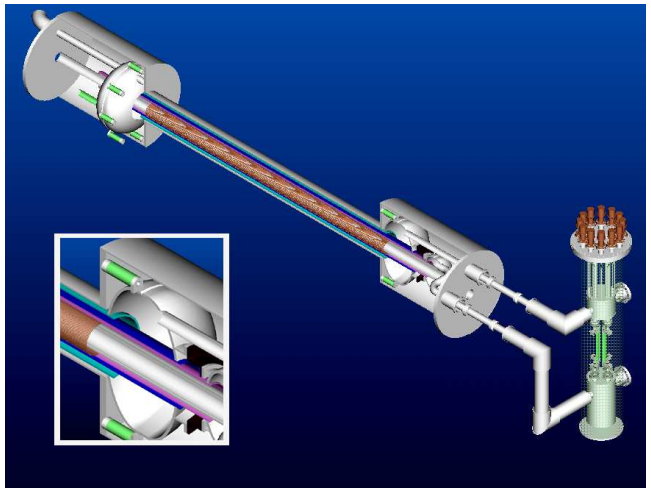


Demonstrate 10 nC, 100 – 300 mA CW rf photo-cathode electron gun:
High power, 700 MHz 2.5 cell cavity (collab. with LANL)

Demonstrate high precision (10 ppm) solenoid

Develop CW s.c. cavity for high intensity beams:
Large bore, 700 MHz cavity with ferrite HOM dampers and high beam break-up threshold (collab. with JLab)





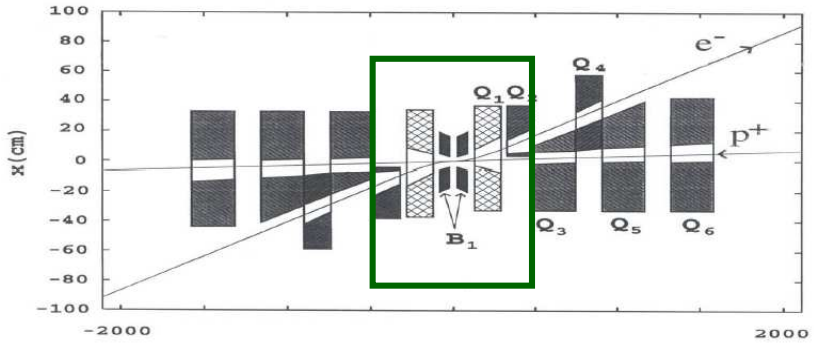
eRHIC collider

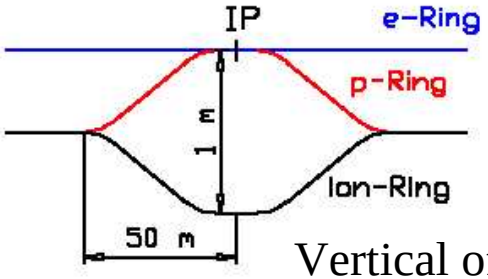
- Collider geometry capable of e-A and polarized e-p collisions
- 10 GeV electron beam $\rightarrow$ $s^{1/2}$ for e-A : 63 GeV/u; $s^{1/2}$ for e-p: 100 GeV
- Range of Ion Species: Pol. Protons, Pol. Neutrons (Pol. He3) $\rightarrow$ U
- Polarization: 70% $\times$ 70%
- Luminosity: 0.5 – 1.0 $\times$ 10^{33} $cm^{-2}s^{-1}$ per nucleon
  - Need electron cooling of RHIC beam
  - Need 10 GeV, ~ 500 mA electron beam

- Ring-ring option (see next slide) based on existing technology. e-ring is very similar to PEP II HER.
- New e-ring fits comfortably on the BNL site

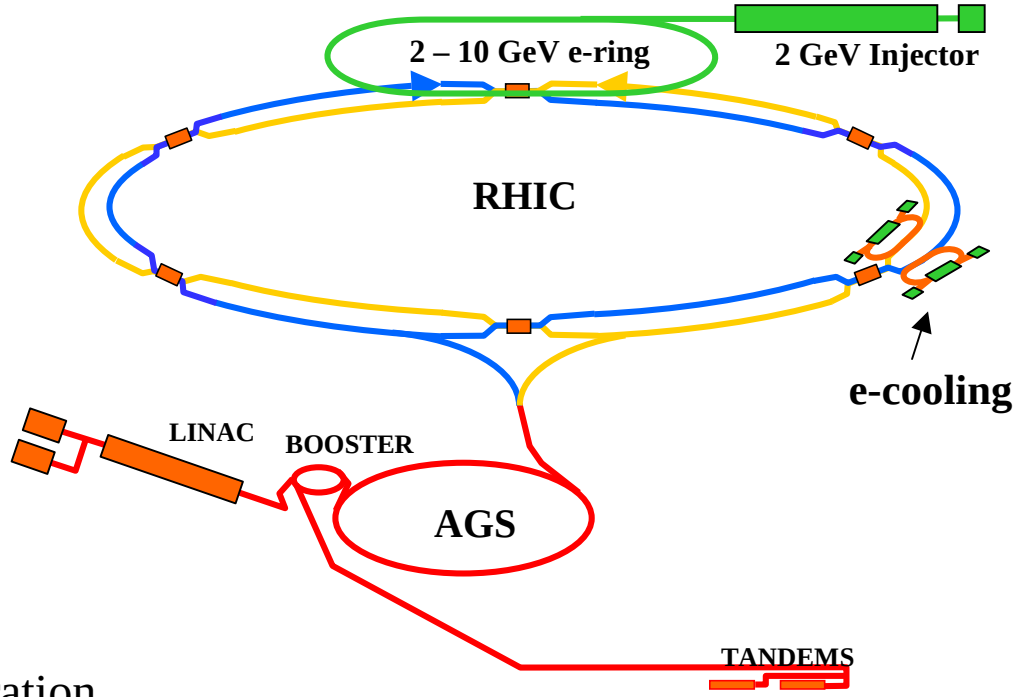
Ring – ring option

- Collisions at one interaction region
- 10 GeV, 0.5 A e-ring with ¼ of RHIC circumference (similar to PEP II HER)
- e-ring with about 15 min. polarization build-up time using super-bends
- Inject at 2 GeV, operate at 5 – 10 GeV
- Existing RHIC interaction region allows for typical asymmetric detector (similar to HERA or PEP II detectors)





Vertical offset
Horizontal separation



Costs and schedule

- R&D and preliminary design (incl. e-cooling, eRHIC, detectors): FY03 – FY08
- Construction FY08 – FY13
- Cost:

Electron-heavy ion collisions:	
10 GeV electron accelerator & storage ring	$200M
Detector for e-p/A collisions	$100M
Intersection region	$ 15M
Heavy ion Luminosity Upgrade:	
Electron beam cooling at full RHIC energy	$ 34M
Detector Upgrades for rare processes	$ 60M
Total Estimated Direct Costs	$409M
EDIA@15%; Conting@25%; ProjG&A@13%	$255M
Total Estimated Costs (w/o escalation)	$664M